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The effectiveness of cervical medial branch radiofrequency neurotomy using a perpendicular approach with a three-tined probe: A single-arm, retrospective cohort study

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ABSTRACT

Background: Cervical medial branch radiofrequency neurotomy (CMBRFN) with a parallel approach has been proven to be an effective treatment for zygapophyseal joint-mediated cervical pain. Technological advancements in radiofrequency probe design have allowed for a perpendicular approach to electrode placement. However, the effectiveness of the perpendicular approach remains to be fully understood.

Objectives: Evaluate the effectiveness of CMBRFN with a perpendicular approach (pCMBRFN) in patients with confirmed zygapophyseal joint-mediated cervical pain.

Methods: This single-arm, retrospective cohort study included patients identified between 2016 and 2022 who underwent pCMBRFN after demonstrating ≥80 % pain relief with two consecutive diagnostic medial branch blocks (MBB). Primary outcomes were ≥50 % patient-reported numeric rating scale (NRS) pain relief and minimal clinically important difference (MCID) on the Pain Disability Quality-Of-Life Questionnaire-Spine (PDQQ-S) at 3 months post-procedure. Secondary outcomes were mean patient-reported retrospective percentage pain relief and duration of relief after a successful pCMBRFN in individuals who presented for repeat pCMBRFN upon return of their symptoms.

Results: A total of 52 participants (63.5 % female; mean age 55.9 ± 10.9 years; mean BMI 26.8 ± 5.2 kg/m^2) were analyzed. At 3 months post-procedure, ≥50 % NRS pain reduction and MCID on PDQQ-S were both reported by 34 patients (65.4 % [95%CI 51.8–76.9]). Of the 34 patients with successful treatment response, 15 had return of symptoms after an average of 8.8 ± 2.5 months with a reported mean percentage pain relief of 86.0 ± 14.9 %.

Conclusion: Within this cohort, pCMBRFN demonstrated effectiveness by reducing pain and disability in over 65 % of patients with confirmed cervical zygapophyseal joint-mediated pain at 3 months. Patients with successful treatment outcomes whose index symptoms eventually returned reported an average pain reduction of 86 % lasting approximately 9 months. Larger prospective studies with long-term follow-up are needed to confirm these results.

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1. Introduction

Neck pain is the sixth-leading cause of chronic disability, ranking behind back pain and depression [1]. Approximately half of all individuals will experience a clinically significant neck pain episode over the course of their lifetime [2]. Cervical zygapophyseal or "facet" joints are considered the primary pain generator in 26–70 % of patients with chronic neck pain [3–6]. First demonstrated in a 1996 randomized controlled trial by Lord et al. [7], cervical medial branch radiofrequency neurotomy (CMBRFN) has been established as a safe and effective treatment for zygapophyseal joint-mediated cervical pain. This seminal study introduced a lesioning technique for cervical medial branch nerve coagulation, positioning conventional RF cannulae parallel to the nerve's course at both oblique and parasagittal angles. This technique is also outlined in the current Interventional Pain and Spine Intervention Society (IPSIS) Practice Guidelines and has been widely adopted [8]. A 2016 systematic review of studies using the parallel approach for CMBRFN reported complete pain relief in 63 % of patients at 6 months and in 38 % at 12 months [9].

Recent technological advancements in radiofrequency probe and cannula design have facilitated alternative approaches to the traditional, parallel technique via altered lesion geometry. Specifically, three-tined cannulae produce relatively large pyramidal lesions, which are widest in diameter at the distal footprint of the tines [10]. This unique lesion geometry permits a perpendicular approach to the targeted nerve. Although utilization of this technology has been studied more extensively in the lumbar spine [11], a perpendicular approach utilizing a three-tined cannula was recently described for CMBRFN in 2023 [12].

Interventional Procedure Follow-up Form

Name:_____ DOB:_____

Date of procedure:_____ Type of Procedure:_____

In order to help maximize the quality of your care, it is important that you fill out this form and return it to us.

Please fill out this form on or about the following date:_____, then deliver, mail or fax it back to our clinic.

Relating to your_____ pain, please record your scores in the 2nd column of this table, averaged for the past week:

	At the time of your procedure		3 months after your procedure	
Pain Intensity: how severe has your pain been? 0 = no pain; 10 = worst possible pain		/10		/10
Pain Frequency: how often has your pain been present? 0 = never present; 10 = always present		/10		/10
Disability: because of your pain, how difficult is it for you to do each of the following activities? 0 = no difficulty; 10 = completely unable to do it Difficulty for:		/10		/10
Difficulty for:		/10		/10
Satisfaction: if you had to live with the pain you have now for the rest of your life, how satisfied would you be? 0 = completely satisfied; 10 = completely unsatisfied		/10		/10
Quality of Life: how much has your pain disrupted the quality of your life? 0 = not at all; 10= completely ruined it		/10		/10
Totals:		/60		/60

Fig. 1. The Pain Disability Quality-of-Life Questionnaire-Spine instrument. Figure reproduced from Amatto *et al.* [15].

Given the novelty of this technique, research regarding its safety and utility in the cervical spine are limited. This study aimed to evaluate the effectiveness of the perpendicular approach to CMBRFN (pCMBRFN) using a three-tined cannula.

2. Methods

2.1. Data collection

In this single group retrospective cohort study, we reviewed electronic medical records of consecutive patients from two Canadian musculoskeletal pain management clinics within a single physiatrist's practice who underwent first-time pCMBRFN with a three-tined cannula between 2016 and 2022. Study approval was granted by the Conjoint Health Research Ethics Board at the University of Calgary (Ethics ID#: REB20-0355). Data extraction was performed by authors (R.B. and A.A). The inclusion criteria were: (a) axial neck pain refractory to conventional conservative management, (b) clinical features suggestive of cervical facet joint-mediated pain, such as pain and tenderness upon palpation over the cervical facet joints, or pain with cervical extension or rotation, (c) dual, concordant fluoroscopically guided medial branch blocks with ≥80 % pain relief, (d) CMBRFN utilizing a perpendicular approach with an 18-gauge Trident cannula with a three-tined, 5-mm active tip (Diros Technology, Inc.), and (e) numeric rating scale (NRS) and Pain Disability Quality-Of-Life Questionnaire-Spine (PDQQ-S) scores captured at baseline and at 3 months post-intervention (Fig. 1). For criterion (c), the response to medial branch blocks was determined by having patients complete a pain diary asking them to rate their pain intensity using an 11-point NRS. Recordings were made just prior to the block procedure and at 30-min intervals for 6 h post-block. Once the diary had been returned to our clinic for review, maximal pain relief was calculated mathematically from the pre-versus post-block NRS pain scores. Patients were included in the study if they achieved at least 80 % pain relief during the 6-h period [13]. Additionally, patients were asked if they experienced any functional improvement or enhanced ability to participate in specific activities, though this was not an inclusion criterion. The exclusion criteria were: (a) prior CMBRFN, (b) diagnostic/prognostic blocks performed off-site (c) confounding interventions or injuries (*e.g.*, epidural or facet joint steroid injection), occurring between the CMBRFN procedure and follow-up, and (d) cervical procedures performed concurrently with another intervention on the same date. Additional demographic variables were collected and analyzed as potential predictors of treatment success, including gender, age, BMI, employment status (working, not working, or retired), and current engagement in regular exercise (yes vs. no).

2.2. Interventional Procedure

All procedures were performed under fluoroscopic guidance by a single experienced physiatrist. Preprocedural sublingual Lorazepam and/or intraprocedural self-administered inhaled nitrous oxide were provided for anxiety and pain control as required. No intravenous sedation was used. With the patient in a lateral decubitus position and a true lateral projection of all target portions of the articular pillar visible on fluoroscopy, the overlying skin and soft tissue were anesthetized with 1–2 mL of 1 % preservative-free lidocaine without epinephrine using a 27- or 30-gauge, 1.5- or 1-inch long needle, respectively. pCMBRFN procedures were performed using a 5- or 10-cm long, 18-gauge three-tined Trident RFN cannula with a 5-mm active tip (Diros Technology Inc, Markham, Ontario, Canada). The Trident cannula was passed through the anesthetized tissue to sit perpendicularly on the periosteum of the mid-point of the waist of the articular pillar for the C3-C6 vertebrae (Fig. 2). For C7, the target point was the base of the superior articular process. For the third occipital nerve, two lesions were created: one slightly superior and one slightly inferior to the mid-point of the C2/3 facet joint line. The tines were deployed, proper placement of the cannula was re-confirmed on the lateral and anterior projections, 0.5 ml of local anesthetic was injected through the cannula, and the thermal lesion was delivered. No motor or sensory stimulation was performed. The lesion temperature was 80 °C and duration was 145 s, which included a 15-s ramp-up time.

2.3. Outcomes

The primary study outcomes were the proportions of participants with ≥50 % NRS reduction and the minimal clinically important difference (MCID) on the Pain Disability Quality-Of-Life Questionnaire-Spine (PDQQ-S) at 3 months post-procedure. The PDQQ-S is a previously validated, six item patient-reported outcome measure designed for use in the field of minimally invasive interventional spine care [14]. A ≥17-point score decrease has been established as the MCID value for this questionnaire [15]. Secondary outcomes included the percentage of mean patient-reported pain relief and duration of improvement after a successful CMBRFN procedure in individuals who reported a return of their index symptoms at subsequent follow-up.

2.4. Data analysis

Data were analyzed using descriptive statistics, with calculated means/standard deviations for continuous variables and frequencies/percentages for categorical variables. We explored the relationships between treatment success, as measured by the two primary outcome

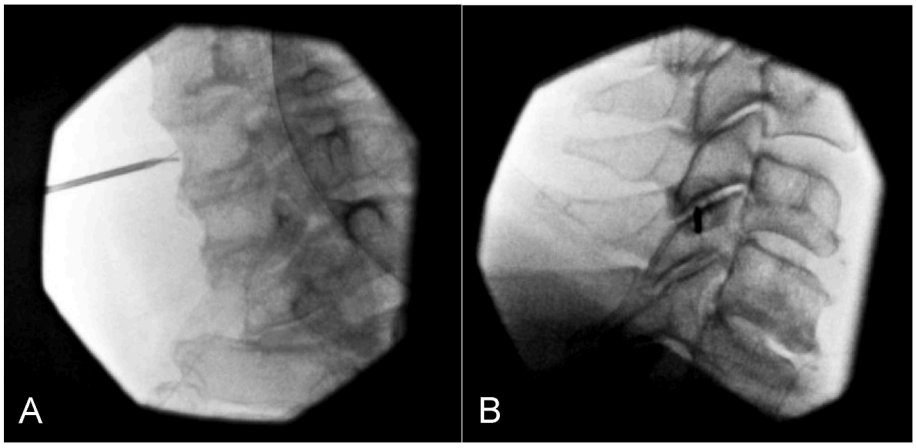

Fig. 2. Fluoroscopic images of the anteroposterior (A) and lateral (B) views of radiofrequency neurotomy of the right C6 medial branch showing multi-tined cannula placement and tine deployment.

variables, and select patient demographics using logistic regression analyses with the calculations of an odds ratio (OR) and its 95 % confidence interval (CI). Predictive variables included as covariates in the logistic regression analyses were sex, age, BMI, current participation in regular exercise (yes vs. no), and working status (yes, no, or retired).

3. Results

A total of 52 consecutive patients met eligibility criteria and were included in the analyses. Patient demographics and clinical characteristics for this cohort are summarized in Table 1. Of the included participants, 63.5 % were female with a mean age of 55.9 ± 10.9 years, mean BMI of 26.8 ± 5.2 kg/m^2, and mean reported pain chronicity of 9.4 ± 10.4 years. Primary and secondary study outcomes for this cohort are presented in Table 2. At 3 months post-procedure, 34 participants (65.4 % [95%CI: 51.8–76.9 %]) each reported ≥50 % NRS pain relief and the MCID (≥17-point score decrease) on the PDQQ-S questionnaire. Of the 34 participants with a positive treatment response, 15 individuals reported return of their index symptoms at a subsequent clinic visit. These 15 patients reported experiencing a mean pain reduction of 86.0 ± 14.9 % for a mean duration of 8.8 ± 2.5 months following pCMBRFN. Results of the logistic regression analyses for ≥50 % NRS pain reduction and MCID on PDQQ-S are detailed in Table 3. None of the analyzed covariates demonstrated statistically significant predictive value ($p > 0.05$) for achieving either of the two primary outcomes used to define treatment success.

4. Discussion

In this retrospective single-arm cohort study, over 65 % of the included patients experienced ≥50 % pain relief at 3-month follow-up after undergoing CMBRFN with a three-tined electrode and perpendicular approach. Additionally, over 65 % of patients reported clinically significant improvement in their disability and quality-of-life by achieving the MCID (≥17-point score reduction) on the PDQQ-S. Among treatment responders who reported a return of index symptoms, average estimated pain relief was 86 % for a mean duration of approximately 9 months post-procedure.

Previous work has demonstrated the effectiveness of multi-tined electrodes for pCMBRFN [16]. This novel perpendicular approach to CMBRFN has several potential advantages over the conventional method including reduced procedure time, reduced radiation exposure, no requirement for prone patient positioning, and less distance between the skin entry point and target. A within-subject comparison study of procedural characteristics of lumbar medial branch radiofrequency neurotomy using a three-tined electrode and perpendicular approach versus a conventional monopolar cannula placed parallel to the medial branch documented significant savings in procedure time and radiation exposure with the three-tined electrode and perpendicular approach compared to the conventional cannula and parallel approach [11].

However, rigorous trials comparing the two techniques in the cervical spine are only just beginning to emerge in the published literature. In 2023, Filiatrault et al. reported results for the only randomized controlled trial of perpendicular CMBRFN with a three-tined electrode published to date [12]. In their study, only 46 % (95%CI: 26–66 %), 25 % (95%CI: 8–42 %), and 17 % (95%CI: 2–33 %) of patients treated with the three-tined cannula reported ≥50 % pain reduction at 3, 6, and 12 months, respectively, compared to 65 % (95%CI: 42–87 %), 61 % (95% CI: 39–84 %), and 71 % (95%CI: 49–92 %) of patients treated with the conventional method, with inter-group differences achieving statistical significance at 6- and 12-month follow-up. The investigators observed no significant differences between the two groups in procedural pain (the primary outcome). Notably, four of the 25 patients allocated to the conventional cannula treatment arm were excluded from the analysis after receiving incomplete CMBRFN procedures: three interventions

Table 1
Patient demographics and clinical characteristics ($N = 52$).

Variable	No. (%)
Gender	
Male	19 (36.5)
Female	33 (63.5)
Smoker	
Yes	8 (18.6)
No	35 (81.4)
Missing	*9*
Exercise	
Yes	26 (60.5)
No	17 (39.5)
Missing	*9*
Working	
Yes	28 (68.3)
No	6 (14.6)
Retired	7 (17.1)
Missing	*11*
Workup	
Internal	43 (82.7)
External	9 (17.3)
Age in yr ($n = 52$); mean (SD)	55.9 (10.9)
Body mass index in kg/m^2 ($n = 39$); mean (SD)	26.8 (5.2)
Pain chronicity in yr ($n = 40$); mean (SD)	9.4 (10.4)

SD = standard deviation.

Table 2
Primary and secondary study outcomes.

Outcome Variable	No. (%)	95 % CI (yes)
≥ 50 % NRS reduction ($n = 52$)		
Yes	34 (65.4)	51.8, 76.9
No	18 (34.6)	
≥ 17 PDQQ-S reduction ($n = 52$)		
Yes	34 (65.4)	51.8, 76.9
No	18 (34.6)	
Retrospective percentage pain relief ($n = 15$); mean (SD)	86.0 (14.9)	
Retrospective duration of improvement in months ($n = 15$); mean (SD)	8.8 (2.5)	

CI = confidence interval; NRS = numeric rating scale; PDQQ-S = Pain Disability Quality-of-Life Questionnaire-Spine; SD = standard deviation.

Table 3
Logistic regression models on ≥50 % NRS reduction and ≥17-point PDQQ-S reduction.

Primary Outcomes	Predictor	OR	95 % CI	*p*
≥50 % NRS reduction[a]	**Gender** (vs. male)			
	Female	3.99	0.71, 22.41	0.12
	Exercise (vs. no)			
	Yes	1.24	0.21, 7.31	0.82
	Working (vs. not working)			
	Yes	0.57	0.07, 4.40	0.59
	Retired	0.63	0.05, 8.94	0.74
	Age	1.02	0.95, 1.10	0.52
	BMI	1.09	0.92, 1.29	0.35
≥17-point PDQQ-S reduction[b]	**Gender** (vs. male)			
	Female	2.28	0.47, 11.19	0.31
	Exercise (vs. no)			
	Yes	0.68	0.11, 4.02	0.67
	Working (vs. not working)			
	Yes	0.98	0.15, 6.64	0.99
	Retired	2.54	0.08, 82.86	0.60
	Age	1.02	0.95, 1.09	0.60
	BMI	1.01	0.87, 1.17	0.89

CI = confidence interval; NRS = numeric rating scale; OR = odds ratio; PDQQ-S = Pain Disability Quality-of-Life Questionnaire-Spine.
[a] $N = 36$; $\chi^2(6) = 2.82$; p = 0.83; Pseudo $R^2 = 0.08$.
[b] $N = 36$; $\chi^2(6) = 1.67$; p = 0.95; Pseudo $R^2 = 0.06$.

were discontinued due to severe procedural pain, while a fourth procedure was aborted when the patient developed transient paresthesia in all four limbs. Both procedural time (35.5 ± 7.3 vs. 58.2 ± 14.8 min) and fluoroscopy time (167.6 ± 76.4 vs. 260.8 ± 123.5 s) were significantly decreased with the perpendicular approach, although radiation dose was still equivalent between the two groups. These published findings provide little insight into the relative superiority of the conventional vs. three-tined approach due to inconsistencies in study methodology, including an inherently unbalanced lesioning protocol in which the conventional group was planned to receive twice as many lesions per nerve (4 per medial branch, 6 for the third occipital nerve) compared to the three-tined group (2 per nerve, 3 for the third occipital nerve). This discrepancy likely contributes to the differences observed in procedural and fluoroscopic time and confounds direct comparisons of the effectiveness between the two techniques. This variability further highlights the difficulty in comparison between the different treatment techniques; however, we postulate that the lesioning protocol in the current study represents a more clinically relevant treatment regimen. Despite these differences, it is important to note that both studies had relatively small sample sizes, indicating that future larger study would provide greater confidence in the accuracy of reported treatment responder rates and other outcome measurements.

4.1. Limitations

This study has several important limitations. Included among these are recognized constraints inherent to retrospective, single-arm cohort study designs, such as the lack of a control group or ability to adjust for potential confounding variables. Our results may not be generalizable to broader populations due to the small size of our study sample, which consisted of patients from a single practice. Information regarding the duration of improvement and retrospective magnitude of pain relief was collected from only those individuals who reported return of index symptoms during the observed period. Previous work has demonstrated that patients who attend follow-up appointments are more likely to experience greater pain and have poorer outcomes [17]. As such, our present understanding of the effectiveness of the procedure is potentially incomplete. Additionally, study follow-up was relatively short at 3 months post-CMBRFN. Further investigation, ideally in the form of larger, prospective clinical trials with longer-term assessment of outcomes, is warranted to compare the effectiveness of three-tined CMBRFN with a perpendicular approach to the conventional parallel technique.

5. Conclusion

Cervical medial branch radiofrequency neurotomy is a relatively safe and effective treatment for zygapophyseal joint-mediated neck pain. Technological advancements in radiofrequency cannula and probe design have allowed for alternative approaches that may confer technical advantages over the conventional parallel approach. In this cohort, over 65 % of individuals treated with three-tined pCMBRFN reported clinically significant reductions in pain and disability at 3 months post-procedure, with mean estimated pain relief of 86 % for nearly 9 months in responders whose index pain eventually returned. Larger, prospective trials with longer-term assessment of outcomes are needed to compare the effectiveness of this novel approach with the established and validated traditional, parallel technique.

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Zachary McCormick reports a relationship with International Pain and Spine Intervention Society that includes: board membership. Zachary McCormick reports a relationship with Avanos Medical Inc that includes: funding grants. Zachary McCormick reports a relationship with Boston Scientific Corporation that includes: funding grants. Zachary McCormick reports a relationship with Saol Therapeutics that includes: funding grants. Zachary McCormick reports a relationship with Spine Biopharma that includes: funding grants. Zachary McCormick reports a relationship with SPR Therapeutics Inc that includes: funding grants. Zachary McCormick reports a relationship with Stratus Medical that includes: funding grants. Zachary McCormick reports a relationship with Saol Therapeutics that includes: consulting or advisory. Zachary McCormick reports a relationship with Stryker that includes: consulting or advisory. Taylor Burnham reports a relationship with Diros Technology Inc that includes: funding grants. Taylor Burnham reports a relationship with Avanos Medical Inc that includes: consulting or advisory. Aaron Conger reports a relationship with Stratus LLC that includes: funding grants. Robert Burnham reports a relationship with International Pain and Spine Intervention Society that includes: funding grants. Founder and CEO of STATIX, LLC an independent research consulting company - Brook Martin Deputy Editor of Evidence and Methods for The Spine Journal - Brook Martin If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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